S. 7.

DRY DOCKS.

With Mr. E. H. Keating's compliments.

REPORTS

ON

PROPOSED DRY DOCK

FOR THE

PORT OF HALIFAX, N. S.,

CONTAINING DESCRIPTIONS OF SEVERAL

STONE, WOODEN AND IRON DOCKS.

Halifax:
NOVA SCOTIA PRINTING COMPANY,
1883.

PRELIMINARY REPORT

ON

THE PROPOSED HALIFAX DRY DOCK,

AND

REPORT

ON

AMERICAN STONE AND WOODEN DOCKS.

BY

E. H. KEATING, M. Inst. C. E.,

Member of the American Society of Civil Engineers.

CITY ENGINEER.

PUBLISHED BY SANCTION OF THE MAYOR AND CITY COUNCIL.

Halifax:

NOVA SCOTIA PRINTING COMPANY,

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PRELIMINARY REPORT

ON THE

Proposed Graving Dock for the Port of Halifax.

CITY ENGINEER'S OFFICE, 6th November, 1882.

The following is a list of the papers which have been sent to me by the City Clerk, together with a copy of a resolution of Council dated 1st November, requiring a report upon the same to the Council at its next meeting :—

1. Letter from W. Cramp & Sons, of New York, dated 31st May, 1882.

2. Letter from J. E. Simpson & Co., of New York, dated 7th June, 1882, containing an offer to build one of "Simpson's Docks," and enclosing prospectus for a "Dry Dock and Improvement Company," on Simpson's plan.

3. Letter from William Morris, Esq., C. E., dated 17th July, 1882, enclosing proposal of Messrs. Kinipple & Morris, M. M. Inst. C. E., dated 15th July, 1882, to form a company to build a Stone Graving Dock.

4. Letter from His Honor the Recorder, dated 17th July, 1882, on the proposal of Messrs. Kinipple & Morris.

5. Report of the Dock Committee, 20th July, 1882, and Report of "The Joint Committee on Dry Dock," 18th July, 1882.

6. Letter from W. Morris, C. E., 15th August, 1882.

7. Letter from W. Morris, C. E., enclosing rough outline plan of Dock, as proposed by Messrs. Kinipple & Morris, dated 10th August, 1882.

1. The letter from Messrs. Cramp, (Ship and Engine Building Company,) of New York, is one recommending "Simpson's Improved Dry Dock." It states that they have owned and operated one of these docks in Philadelphia "for the past six

years without intermission," and also that they have operated another of the same description during the past winter, and through the most unfavorable weather in Brooklyn, N. Y., "with the most satisfactory results." It condemns stone as a material of construction for docks in a cold and changeable climate, and advocates the use of wood, of which Simpson's docks are composed.

2. J. E. Simpson & Co.'s letter is an offer to build one of "Simpson's Improved Docks," having a

Length at top of	650 feet.
Width at coping level	135 "
Width at bottom	50 "
Depth from coping to bottom	32 "
Draught of water from keel blocks to highest tide level	26 "

The proposal includes the erection of suitable buildings for Engine House, Repair Shops, &c. They stipulate that the site must be acceptable to them, and ask the sum of $800,000 for the dock and works complete, providing the cost of the site will not exceed $25,000. The offer is based upon the condition that the company shall receive in subsidies $10,000 per annum from the Imperial Government, and a like sum from the Dominion and City Governments, or in all $30,000 per annum for a period of 20 years.

3. The proposal of Messrs. Kinipple & Morris, M. M. Inst. C. E., is to form a company with a capital of $1,000,000, to build a stone dock 560 ft. in length, 100 ft. wide at coping level, with 26 feet depth of water over cill of entrance at ordinary high water, spring tides, 24 feet 6 inches depth at head, and the entrance to be 78 feet in width.

The company reserve the right to select any site for the works within the limits of the City, and the proposal is made "subject to the approval of certain capitalists in England," and upon the condition that the subsidies from both the Dominion Government and the City be increased from $10,000 per annum each for 20 years to $13,750 each for 22 years after the completion of the dock, and also that the subsidies shall be paid *pro rata* from the time that the company shall have expended $50,000 until completion, the term of four years being allowed for construction.

There are 21 stipulations in the proposal, to which, for the sake of brevity, I must refer to the document itself.

4. The Recorder's letter has reference to the proposal of Messrs. Kinipple & Morris only. It calls attention to the impracticability of paying the subsidies as stipulated; to there being no provision to ensure the construction of the dock

according to the terms of the proposal; to the nature of the materials to be used and the class of the dock not being stated in terms which he considers sufficiently definite; to the absence of any provision as to keeping the dock in proper repair; to the question of taxation; to the fact that no date is fixed for the commencement of the work; and to the advisability of inserting a clause specifying the time during which the agreement shall be binding.

5. The Report of the "Dry Dock Committee" makes no recommendation. It deals solely with the proposal of Messrs. Kinipple & Morris, and the Committee submit the scheme to the consideration of the Council. The Report of the "Joint Committee" is of the same nature.

6. Mr. Morris' letter of 15th August calls attention to the necessity of an early decision on the part of the City Council, so that the necessary plans and specifications may be prepared during the coming winter, and the works commenced early next spring.

7. The outline plan of the dock submitted by Messrs. Kinipple & Morris, is a small scale drawing or sketch, on tracing linen, illustrating a stone dock substantially in accordance with their written proposal.

I presume, judging from the short time that has been given me to report upon the above papers, that I am not expected to enter upon the questions of "subsidy" and the financial aspects of the two proposed schemes.

The offer of J. & E. Simpson & Co. is in my opinion, too vague to be dealt with in its present shape. There are many points of importance to the City to which no allusion has been made, the length, width and depth of the dock being the only things definitely stated. Provision is made that plans will hereafter be submitted but there is no stipulation that they shall be subject to the approval of the Council, and the kind of materials to be used in construction is not stated. Messrs. Simpson have also submitted a series of photographs of their docks in New York and Philadelphia, which give a good general idea of the nature and character of those works. The sides, which incline at an angle of about 45 degrees, are composed of a series of wooden steps or altars, which in some cases extend from the wooden floor up to the surface, in others the wood is discontinued at tide level, and the altars are continued upwards in concrete to the coping, which is also of concrete. The entrances are closed with ordinary ship caissons of wrought iron, which are floated in and out of position, and are operated by manual labour, capstans being placed near the entrance to the dock to facilitate the work. The advantages claimed for Simpson's docks, over those having

sides less inclined, are said to be that men can enter or leave at any point; that the facilities for shoring a ship are better than in any other description of dock, and consequently that the expense of operating the dock is greatly reduced; that materials can be deposited in or taken out of the structure readily at any point. and that by having the sides sloping, a full flood of light and air is admitted to the bottom of the ship while in dock.

The proposal of Messrs. Kinipple & Morris is much more full than that of Messrs. Simpson, and the sketch plan submitted enables a good estimate to be formed of the character of the dock which they propose. The scheme has been so thoroughly discussed before the Committees to whom it was referred, as well as before the City Council and a public meeting called specially for its consideration, that I feel it would be superfluous for me to attempt to ventilate it more fully than has already been done.

As regards the proposed plan of the dock, the entrance is made wider than is usual, in order to accommodate the largest class of war vessel, and the bottom of the dock is shown to be 80 feet in width. The walls, I understand, are intended to be built of either rubble masonry or concrete, faced with native granite; the entrance to be closed by a wrought iron sliding caisson, which can be drawn into a recess or chamber at one side, built for its reception.

The means provided for gaining access to the dock are two stairways at the stern, one on each side at about 160 feet from the entrance, and two at the head of the dock. Timber slides (of which there are four in all) are placed alongside of the stairways at the sides and head of the dock. It appears to me that the structure would be a more convenient one for the purposes for which it is intended, if additional means of ingress and egress and more timber slides were provided, say at least three stairways with timber slides on each side of the dock, instead of one as proposed. This would add a little to the cost of the work, and the company may consider it a matter purely for their own consideration, but in an undertaking intended for the benefit of the port, the City may fairly claim that it should be made as convenient as possible. The plans do not show what the thickness of the walls is intended to be; this is a most important point in a climate such as this, which is subject to great and sudden changes, and where the frost acts so disastrously upon ordinary retaining walls, where proper precautions have not been taken to guard against its effects. I have no doubt, however, that the matter will be properly dealt with by the eminent engineers who are the chief movers in this proposal. If the excavations should be in rock, walls of a much less thickness will answer than if in ordinary soil, and as no site has yet been selected, it is impossible at present to determine

definitely what thickness should be adopted. Attention is, however, called to the question to show the importance of stipulating that the dock shall always be kept in repair and working order.

One of the matters of which I think, the Council should be informed is, that in the proposal of Messrs. Kinipple & Morris the subsidies may extend over a period of twenty-six years instead of twenty-five years, as is now supposed. Another is, that if the proposal is to be adopted, the company should be induced, if possible, to undertake the completion of the works in less than four years.

The only way to ensure having the dock built and completed in a satisfactory manner is to make it conditional that the plans and specifications shall be subject to the approval of the City Council.

As the inducement in offering a large subsidy is that the dock will increase the trade and prosperity of the port, it does not seem unreasonable that the City should have a voice in determining the charges for docking vessels, as it is clear the lower these are made the more vessels are likely to come to the port for the purpose of repairs. The dock charges in New York are said to be 20 cents per ton on the vessels registered tonnage for the first day, and from 15 cents to 18 cents per ton for each succeeding day; a ship of 5,000 tons would therefore pay $1,000 for the first day and from $750 to $900 for each day it remained in dock afterwards. These charges seem to be enormous, and if the Halifax dock is to enter into successful competition with others, the rates should be made sufficiently low to draw ships a little out of their way to this port for the sake of the saving which would be effected.

In order that much time be not lost in docking a vessel, there are many matters of detail which need careful consideration in designing the structure and its necessary appliances. Whether the caisson should be a floating or sliding one, is a question of some importance, the former being the cheapest in first cost, while the latter is a less expensive one to operate. There are advantages and disadvantages peculiar to each which can only be properly understood by inspection and a minute enquiry into the merits of both.

The dock, when full of water, will contain approximately from 7,000,000 to 8,000,000 gallons, and in order to empty this enormous quantity of water rapidly, very heavy pumping machinery is necessary. The Messrs. Simpson use centrifugal pumps, which I believe to be the best and most effective for dock purposes, and also very much cheaper than any other style. Messrs. Kinipple & Morris, although it is not stated in their proposal, I believe, intend to adopt plunger pumps, as they have

done elsewhere. In any scheme that may be adopted, it should be clearly understood before hand what length of time will be required to pump out the dock when full to high water spring tides.

As the proposed dock will be an exceptionally long one, it seems to me that it would be a good plan to build one or two or more stops in the interior, so that the caisson could readily be shifted up nearer to the head for the accommodation of small ships, and so as to avoid a large amount of pumping which would otherwise be necessary.

It has been proposed that a delegation should be sent to examine some of the existing dry docks in ports along the Atlantic coast, and to report upon what plan they would recommend. I have no doubt that a great deal of practical and useful information may be obtained by the adoption of this suggestion.

There are two principle things which tend to make the construction of dry docks expensive, and these are, difficulties in obtaining a good, solid, and even foundation, and in keeping out the water during the construction of the lower parts of the works. It is not likely that there will be much trouble in obtaining a good foundation anywhere within the City limits, but there may be great difficulty in dealing with the water.

A comparison of the cost of a number of graving docks in England and America, shows that it varies from about $5.00 to $24.00 per cubic yard of the sectional accommodation. (The great depth and the difficulties of dealing with the water and the foundations of some docks, as compared with others, must naturally affect this comparison largely.) The proposed dock for this port may be assumed to have a sectional capacity of about 50,000 cubic yards which, at the lower estimate of $5.00, would make the probable cost $250,000 ; at the higher estimate the cost would be $1,200,000.

Before any reliable or tolerably close estimate of the probable cost can be made, it will be necessary to have the site selected, careful and accurate soundings and borings taken and the plan and principal details definitely settled.

I would add that it might be well to consider if the interests of the City should not be guarded in some way in the event of the dock falling into decay or disuse after the expiration of the time limited for the payment of the subsidies.

Respectfully submitted.

E. H. KEATING,

City Engineer.

REPORT

ON

AMERICAN DRY DOCKS.

REPORT

ON AN

Official Inspection of several American Graving Docks, with a view to Determine the Best Description of Dock for the Port of Halifax, N. S.

CITY ENGINEER'S OFFICE,
Halifax, N. S., 22nd January, 1883.

TO HIS WORSHIP THE MAYOR AND CITY COUNCIL:

Gentlemen,—In compliance with your instructions, I have recently visited all the permanent graving or dry docks south of this Port, as far as Baltimore.

As far as I have been able to ascertain, there are only twelve permanent dry docks along the Atlantic coast of North America, and but two of these are capable of taking in the largest ocean steamships.

These docks are situated at the following ports:

2 at Portland, Maine.
4 at Boston, Massachusetts.
3 at New York, N. Y.
1 at Philadelphia, Pennsylvania.
1 at Baltimore, Maryland.
1 at Norfolk, Virginia.

Three of these are stone docks, the others are timber structures.

The stone docks are all old structures, the last one built having been finished in August, 1851. They are the property of the United States Government, and were constructed for the accommodation of ships of war. The wooden docks were all built by J. E. Simpson & Co., and range from two to twenty-nine years old. In addition to these, there is, I am informed, a large graving dock on the Pacific coast, built in the solid rock, and faced with wood. The United States Government are also building a concrete dock faced with granite at Mare Island, California.

There are no graving docks in Canada for the accommodation of ocean shipping, but two are now in course of construction, one at Quebec and one at Esquimalt, British Columbia. Both of these are to be stone structures.

The above are all the permanent dry docks in North America (for the use of ocean ships) of which I have been able to obtain any information. The docks visited by me were at Quebec, Portland, Boston, New York, Philadelphia and Baltimore.

THE QUEBEC DRY DOCK.

This dock is being constructed under an Act of the Dominion Parliament, 38 Victoria, Chapter 56. As I understand this Act, the Government of Canada has undertaken to raise by loan $500,000, and to hand this money over to the Quebec Harbour Commissioners in instalments as may be required for the purposes of construction. The net income received in rates, tolls and dues (which I presume is the balance left after paying running expenses) is to be paid by the Commissioners to the Dominion Government, and to be used—so far as it will go—in the payment of interest at 5 per cent. on the $500,000 and to the formation of a sinking fund. In the event of the money so paid by the Commissioners to the Government not being sufficient to meet the interest in any year, the Commissioners must provide out of any other funds at their disposal a sum not exceeding $10,000 per annum, if the state of their finances will permit of this being done. If Halifax could obtain a loan of an equal amount on similar favorable terms, it is perhaps needless to point out that no City subsidy would be required.

The dock is completed for about two-thirds of its length, measured from the head, and as far as could be inspected at the date of my visit (24th November last) the work done appeared of excellent character. Unfortunately, there were a few inches of snow upon the top of the masonry. Building operations had ceased for the season, and the works were flooded with water to the depth of about twelve feet above the floor of the dock. The most difficult and important portion of the dock at the entrance, the engine house and the chimney have yet to be built, but all the materials are on the ground, and the Engineer expects to bring the whole to successful completion by the close of the next working season. A great deal of difficulty was encountered—in preparing for the construction of the caisson chamber and other portions of the work near the entrance—by reason of inequalities in the bottom and sand, entailing an additional expense of about $70,000 for a new coffer dam.

Work was commenced upon this dock in November, 1877, and by the contract was to have been completed on the 1st June,

1882, for $330,953.89, not including the caisson and pumping machinery, the contracts for which amounted to $61,331.45, or a total of $392,285.34; to this must be added other sums, as given in table C. following, and the foot-note under it, as it is now estimated that the total cost of the works on completion will amount to about $600,000.

$375,000 have been expended up to date, and of this sum the entrance works and portions of the dock yet incomplete have cost about $100,000.

Dredging is done for $1 per cubic yard, and the excavations, which are nearly all rock, are taken out under the contract at 60 cents per yard, or about one-half what the cost would be in Halifax.

The walls are built of Portland cement concrete, which costs $4 per cubic yard, and these walls are faced with heavy blocks of lime stone, from the quarries of St. Vincent de Paul, near Montreal. The stone has to be brought about 120 miles by rail, and the price paid for it—built in place—is about $15 for the cubic yard, or about the same as granite would cost in this city.

Owing to the extreme rise and fall of the tides at Quebec, it is not intended to start the pumps in operation until the water falls to near low-tide level. This arrangement, although no doubt good in Quebec, would not answer here, as it entails great loss of time in docking a ship.

By the official published returns it appears that the harbour of Quebec was closed against navigation, by ice, from 27th November, 1880, to the 26th April, 1881, and was again closed on the 28th November, 1881. It is evident, therefore, that the dock must remain sealed and useless for five months out of the year, and further that, although it is located in a colder climate than ours, it can never be subjected to the same severe tests which a similar structure would undergo in this Port, because here it would be required for constant use throughout the whole year, while there all the portions of the dock below tide level are protected from the action of frost by being submerged.

Details as to the size of this and other docks, the dates of commencement and completion, the description and capacity of the pumps, cost, and amount of business done by each, the rise and fall of tides, and other particulars will be found in the tables A. B. and C. following.

PORTLAND DRY DOCKS.

The construction of a large wooden dry dock at Portland was undertaken by a local company in 1866, on an estimated cost of $145,000. After the necessary lands had been secured, and building operations were about to commence a large portion of the city was destroyed by fire. The dock promoters and

shareholders being heavy losers by this fire, sold their lands, works and charter to J. E. Simpson & Co., who, in 1870, completed the dock—as far as I can learn—upon the same plan as was originally contemplated.

This, like all other of Simpson's docks, rests upon a pile foundation. The excavations were in soft material, represented as mud and silt. The site selected was out in the harbor at a place where the water was shallow. A coffer dam was first constructed surrounding the whole of the proposed dock, the excavations were then made within this enclosure, and the building operations were then carried on without any serious difficulty. The foundation piles are of spruce, spaced a few feet apart; heavy squared timbers running transversely across the dock, rest upon the top of the piles; these timbers constitute the frame-work or skeleton of the dock, they are firmly secured to the heads of the piles and to land-ties along the sides, so as to overcome any tendency there might be to collapse or to thrust the sides of the structure inwards. Additional piles are driven along the bottom to support the keel-blocks. The transverse timbers, where they run from the bottom of the dock to the top, slope at an angle of about 45 degrees, and are termed braces. Upon these braces the altars which form the sides of the dock are laid and secured, they are composed of ordinary pine and spruce, and have now been in the work about 13 years, during which time very little money has been expended in repairs. There are some signs of decay now visible in the wood above tide-level, and in my judgment a few thousands of dollars will before long have to be expended to maintain the structure in a good state of repair. As the wooden altars which form the inside face of the dock were carried upwards—in the construction—clay puddle was rammed in solidly behind them for a few feet in thickness.

All of the wooden docks along the Atlantic coast of America have been built substantially in the above manner, the clay puddle back of the altars and the outside coffer dam—which is left in place as far as it can be—being depended upon to keep the structures tight.

The entrance is closed by a floating wooden caisson, which fits in a groove against a rubber packing and forms a perfectly tight joint. From two to three men usually handle the caisson in ordinary weather, but if it should be blowing hard while being moved more are sometimes required.

The permanent staff consists of three men, the Dock Master, the Engineer and the Fireman, who also operate a smaller dock, No. 2, which is situated along side of the above, or No. 1 dock. Both of these docks are now owned and operated by the same company, who purchased the works a little more than a year

ago. No. 2 dock is somewhat differently constructed from No. 1, the sides being planked instead of arranged in low altars and the entrance is closed by a lowering gate, hinged at the bottom, and over which the vessels pass to enter the dock.

The accompanying tables give all the further information which I have been able to obtain respecting each of these docks. Some of my questions could not be answered by the dock officials, as the present company has been in possession of the works for but a short period of time. Four steamers, two ships and two barques were docked during the month of November last by the company, and both docks are said to be kept pretty steadily employed, although it is also stated that the works do not pay a fair rate of interest on the money invested in them.

CHARLESTOWN NAVY-YARD DOCK—BOSTON.

This appears to have been the first permanent dry dock built in North America. It was commenced in 1827 and finished in 1832, at a cost of $677,000. The walls are of heavy masonry, faced with dressed granite and backed with rubble. The dock was lengthened 65 feet in 1857–8 and 9, at a cost of $223,000. Nearly $73,000 have been expended in repairs to the pumps, engines, gates and masonry since 1860, and, I understand, trifling amounts previous to that date. Of this latter amount spent in repairs, it is stated that about $27,000 was wasted on the masonry alone, but the circumstances under which this happened were not fully explained. If, however, this statement is correct, the proper amount to place for repairs would be $46,000 (instead of $73,000) which would give about $900, or one-tenth of one per cent. per annum for this item.

The entrance is closed by a pair of wooden gates and also a floating wooden caisson, both of which have been in use since the dock was completed, or for a period of fifty years, but they will not be of service much longer. Sea worms have not attacked the woodwork, owing to the water in the vicinity being largely impregnated with sewage.

Generally speaking, the masonry is in fair condition, except at the entrance, where it has been injured by an accident. Some of the joints have been opened by the action of frost, and there is some leakage along the bottom of the walls and at the head, but nothing of a serious nature. The total amount estimated as now required for repairs—by the dock officials—is $65,000; but from this amount $8,000 for new gates and $32,000 for a new caisson must be deducted in order to arrive at the estimated cost of repairs to the masonry, which will then stand at $25,000.

It is a well known fact that Governments are, as a rule, more liberal in their expenditures of money on engineering works than

private corporations, and my opinion is that if this dock were in the hands of a company, the whole, or at least the greater part of the contemplated expenditure of $25,000 would be saved for many years to come.

EAST BOSTON DRY DOCKS.

There are three timber dry docks lying side by side at East Boston, which are owned and operated by a private company. Ships are not repaired by the company and they have no warehouses for the storage of cargoes in the vicinity of their docks. The working expenses are given at $1,000 per month, not including rates and taxes, or at $2,000 including these, and the earnings are said to range from $2,000 to $4,500 per month. The capital stock is $350,000, and the works are said to pay five per cent. in dividends. For repairs and renewals the Secretary of the company thinks an allowance of one-half per cent. or about $1,750 per annum would be ample to cover every contingency.

The permanent staff to work the three docks consists of five men—Superintendent, Dock Master, Engineer, Fireman and Watchman, extra hands being hired temporily when needed.

No. 1 Dock, which is the largest, can accommodate a ship up to about 350 feet in length over all on deck. No. 2 is the next in size and No. 3 is the smallest. The dimensions of all will found in table A.

All three have been built much upon the same plan, or in the same manner as that described for No. 1 Dock at Portland, except that they were constructed partly inland. The altars which form the sides slope at an angle of about 45 degrees and rest upon the braces which again are secured to the tops of the piles. The bottom is silt and clay, and spruce pile foundations have been used throughout. The backing in these as well as in all the other timber docks along the Atlantic coast, is stiff clay puddle of a few feet in thickness.

All the three entrances are closed by wooden swinging gates (operated by chains and capstans,) which will soon require extensive repairs.

No. 1 Dock was completed in June, 1864. The altars are of ordinary white pine and spruce, and the floor is hardwood. Little money has been spent upon this structure since its completion, repairs having been confined almost solely to the altars above tide level. The woodwork below tide is still in good condition.

No. 2 Dock was finished in November, 1854. The braces, floor and altars are all of spruce. It is stated that but slight repairs to this dock have ever been made, and that these were chiefly to the altars and braces above tide level and the wooden

coping. The dock is still in working order, but some repairs seem to be needed. As far as outward appearances go, I would judge that about $6,000 would cover the cost of repairs, assuming labour and materials to be at average Halifax prices. It is, however, possible that the braces and heads of the piles may on examination be found to be so decayed as to more than double this estimate. It would be impossible for the most experienced expert to make any close estimate of the probable cost of work of this nature unless portions of the face timbers were removed, so that a thorough examination could be had of the interior.

No. 3. Dock was completed in July, 1855. I do not know what kind of wood was originally used for the internal face work, but probably it was ordinary spruce, as the whole had to be renewed in 1875. The new altars are mostly of white pine, and the dock is now in good condition.

Why the entire face of this dock should have required renewing after the lapse of 20 years, while such has not been needed in No. 2 dock, which is a year older, does not appear at all clear—however—the statements are given as they were received from those who profess to know the history of the works.

THE DRY DOCK AT BROOKLYN NAVY-YARD, NEW YORK.

This dock was commenced in 1844, and finished in August, 1851, at a total cost of $2,151,173.61. From this sum, however, must be deducted $147,675 for tools and machinery, &c., sold after completion of the work, and for buildings erected and used for other than dock purposes.

The entrance is c' sed by iron swinging gates, and an iron floating caisson, upon which about $21,000 have recently been spent in repairs. From 1871 to 1881 the repairs to the dock cost $14,637, and I cannot find that any other sums have been expended on this item.

The walls are of very heavy masonry, the face and altars being neatly worked granite, and the backing composed of blocks of granite.

By examing table C. it will be seen that the prices paid for nearly every item in the work were excessive in the extreme. This coupled with the fact that great difficulty was experienced in preparing for and getting in the foundations, owing to the treacherous nature of the bottom, is sufficient to account for the enormous cost of the works.

The masonry of this dock has always given trouble; it leaks badly in many places, and several of the stones have been so heaved by the frost that the joints have opened from about ¼ths of an inch to an inch in width. The attempt has been made,

both here and at the Boston stone dock, to caulk the open joints with lead, the effect of which, in my opinion, has been to make matters worse, as the water, instead of having a free outlet, was held in the masonry, and between the face stones and the backing. Of course, when the frost came, the inevitable result would be that the face stones would be pushed further out than before.

It is estimated that about $60,000 are required to repair the masonry, but it would appear to me preferable to spend a larger amount and, if possible remove the water from behind the walls which is apparently the cause of all the trouble.

On examining the plans of this and the other American stone dry docks, I could not find that any provision had been made for arterial or underdrainage, and this is sufficient to account—in a great measure—for the leakage and subsequent troubles which have been experienced. Another matter to be borne in mind in connection with these docks is that they were constructed before the invaluable properties of Portland cement—for works of this nature—had become known to engineers.

THE CRAMP'S DRY DOCKS, BROOKLYN, NEW YORK.

These docks lie beside each other in Erie Basin, and are pumped out by the same pumps and engines. They are two in number and are known as No. 1 and No. 2 dock. Each is a wooden structure built by J. E. Simpson & Co, and finished in 1866. The bottom was tough clay and stones, and the piles which support the structures were driven into it from 15 to 22 feet below floor level. It having been found that these docks were not large enough, No. 1 was lengthened 30 and deepened 3 feet, and No. 2 was lengthened 110 and deepened 4 feet. The original cost, including repairs, is given as $783,356, and the alterations are said to have cost $500,000.

The peculiarity of these docks is that the coping and the five short altars at the top are in monolithic concrete, otherwise the construction is the same as the wooden docks elsewhere. The timber in No. 1 Dock is said to be of different kinds of wood, and in No. 2 to be all of Southern or Georgia pine. The entrances are closed by wrought-iron floating caissons, the pumps in which are worked by steam carried underground from the main boiler house. Either caisson, it is said, can be easily handled by three men in any weather, and eight men in all are needed to dock the largest ship that can enter either structure. These docks are the largest in America, they were leased by "The William Cramp & Son's, Ship and Engine Building Co." of New York and Philadelphia, a few years ago. The heads of the firm not only give them the highest praise but contemplate shortly building another dock of the same description.

There can be no question that these docks possess great merits. There is plenty of light and air in them, and they soon dry after being pumped out, as—from their flaring sides—the sun can shine directly into them from almost any quarter. Another and a very important advantage is, that by the adoption of short and narrow altars it is never necessary to cut the shores which hold a ship in position—as must be done in a dock with nearly vertical sides or of the ordinary shape—because, if a shore is found to be too long or too short when placed on any altar, it has only to be raised or lowed to another, which is the work of a moment. This at first sight seems trivial, but if a dock has much business to do and the shores have to be constantly cut to fit ships of different traverse section, the amount of timber consumed and the waste of time would form no inconsiderable item in the working expenses. The short and narrow altars also convert each side of the dock into a broad staircase, the width of which is nearly the length of the dock. The advantage of this arrangement as affording the utmost facility to workmen—which means saving in the expense of repairs to shipping—will be self-evident.

The actual cost of docking a ship, including coals and all labour—as will be seen in the tables—is very small. The Messrs. Cramp went to some trouble to furnish me with the exact figures and give $21.68 as the cost for a vessel of 3,000 tons.

On the 9th of December I was fortunately able to witness the whole operation of placing an ocean steamship in one of these docks, and was much struck with the rapidity and ease with which every detail of the work was performed. It took 30 minutes to bring the ship into the dock and place her in her proper position; the pumps were then started, and the dock was emptied in just 2½ hours.

The lessees, as a rule, do all the repairs needed to the ships occupying their docks, but shipmasters and owners are not prohibited from doing their own repairs or work, or from bringing in outside mechanics and laborers if they wish.

At the Port of New York (including Brooklyn and New Jersey) there are, I am informed, besides the above docks,

1 large Wooden Balance or Floating Dock, about 300 feet long.
1 large Sectional Dock, of wood.
2 smaller Docks of the same kind.
3 Screw Docks for vessels from 150 to 1,000 tons.
10 small Wooden Floating Docks, and
1 of "Kirkham's Patent Coffer Dams."

THE CRAMPS' DOCK, PHILADELPHIA.

The excavations for this dock were through disintegrated gneiss, almost approaching in texture a heavy clay. This material gradually became harder as the digging proceeded downwards, until at about ten to fifteen feet below the bottom of the dock it became so hard that the piles which were driven into it had to be capped and pointed with iron, and the "Gunpowder Process" was resorted to to drive them, as it was considered the quickest and best. The dock is a wooden structure throughout, with the usual clay puddle for backing, and an iron floating caisson to close the entrance. The altars are of "Georgia pine," known in Halifax as "pitch pine," and are carried up to the surface of the ground in the manner customary in American wooden docks. It was commenced in September, 1875, was nine months in building, and cost about $300,000. The repairs account so far amounts to nothing, and the dock is in excellent condition. The number of hands employed to dock a ship is nine, and their services are utilized to operate a marine slip as well, which is situated alongside.

BALTIMORE DRY DOCK.

This is a wooden structure; it was commenced in May, 1879, and finished about 14 months afterwards, and is almost a *fac simile* of the dock last described. The excavations were mostly through tough clay, and the piles were driven into similar material in the bottom about 25 feet. Two pile piers extend out about 200 feet on each side of the entrance, and extensive repairing shops for the accommodation of shipping and a large warehouse for the storage of goods have also been erected in the immediate vicinity.

The whole works, including dock, engine and boiler-house, offices, repairing shops, warehouse and piers, &c., cost $365,500. They are now leased for ten years to a private firm, who pay six per cent. per annum, or about $22,000, in rental.

The promoters of this dock were "The Baltimore and Ohio Railroad Co.," who, looking solely at the interests of their own road, guaranteed the subscriptions to the stock, and took the entire bonds of the Dock Company. The railroad company saw that the traffic on their own lines must depend—at least to some extent—upon the facilities offered at their ocean terminus for the repair of shipping, as ship-owners and underwriters, when possible, invariably avoid a port destitute of such facilities, and the company did not hesitate to assume the whole responsibility.

I need scarcely point out the weight of a similar argument when applied to the Intercolonial Railway and the port of Halifax.

The United States Government are also interested in this dock, as it is built upon part of the lands of one of their fortifications. The Government granted to the Dock Company about fourteen acres of ground and water, being part of the Fort McHenry tract, on condition that the Company "construct "within two years * * * an efficient 'Simpson's Improved "Dry Dock,' * * * and to accord to the United States the "right to the use forever of the said dry dock, at any time, for "the prompt examination and repair of vessels belonging to the "United States, free from charge for docking; and if at any "time the said property hereby conveyed shall be diverted to "any other use than that herein named, or if the said dry dock "shall be at any time unfit for use for a period of six months or "more, the property hereby conveyed, with all its privileges and "appurtenances, shall revert to and become the absolute property "of the United States."

It should, perhaps, be explained that the condition, "free of charge for docking" is not intended to convey the meaning that the Government ships may remain in dock for an unlimited time free of charge, but simply that the first cost of the actual operations required to place the ship safely in dock shall be free, and that after that rates and dues may be charged in the usual manner. As it costs at this dock only about $30 to dock a ship, it will be seen that the Company are not very heavy losers.

In addition to the above dry dock, there are at the Port of Baltimore one marine slip capable of taking a vessel of 1,200 tons, and a number of smaller ones, the largest of which has only a capacity of about 600 tons. There is also a sectional dock for ships up to about 1,300 tons.

The opinions of experts, of officers connected with the Bureau of Yards and Docks, and of others, in relation to wooden and stone docks, would add so much to the length of this report that they are omitted; they can, however, be given in detail at any future time if required.

TABLE A.—*Giving the dimensions of the principal Graving Docks in the United States, and of the Dock at Quebec.*

	PLACE.	Number.	Material of construction.	Distance lengthened.	Depth deepened.	Length in bottom, from inner groove to head.	Length on top from inner groove to head.	Length on top from outer groove or abutment to head.	Width on top in body.	Width on floor in body.	Width of entrance at coping.	Width of entrance at bottom.	Depth of gate sill below coping.	Depth of sill below ordinary high tide.	Ordinary rise and fall of tides	Extreme rise and fall of tides	REMARKS.
				ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	
1	Quebec	1	Stone	0	1	533	534⅛	551⅛	100	72	68	65½	33½	26½	14	22	Not yet completed.
2	Portland	1	Wood	0	0	390	425	425	100	45	80	45	27	22	9	11	Finished in 1870.
3	"	2	Wood	0	0	180	200	200	80	40	40	40	17	12	9	11	" 1871.
4	Charlestown Navy Yard	1	Stone	65	0	293	318	389	80	30	60	44	30	25	11	13	Finished in 1832 and extended 65 ft. in 1857 8-9.
5	Boston	1	Wood	0	0	340	365	365	100	45	68	68	24	18	9	11	Finished in 1864.
6	"	2	Wood	0	0	240	250	250	75	45	45	45	22	16	9	11	" 1854.
7	"	3	Wood	0	0	155	165	165	45	30	35	35	21	15	9	11	" 1855. Woodwork renewed in 1875.
8	Brooklyn Navy Yard, N.Y.	1	Stone	0	0	328	358	370	100	30	68	48	30	25½	4½	12	Finished in 1851.
9	Cramp's Dock, Brooklyn	1	Wood	30	3	465	500	520	124	52	100	46	26	22	5½	9	" 1866. Length'd and deepened 1881
10	" "	2	Wood	110	4	567½	600	620	115	46	85	45	30	25	5½	9	" 1866. Length'd and deepened 1881
11	" Philadelphia	1	Wood	0	0	415	430	450	111	45	70	48	24	20	6	.....	Finished in 1876.
12	Baltimore	1	Wood	0	0	437	450	470	111	45	80	48	27	22	1½	.....	" 1880.
13	Mare Island, California.	1	Stone	0	0	438	475	495	104	30	78	.....	32	26½	5	.....	Not yet completed.
14	Norfolk Navy yard	1	Stone	0	0	261	290	290	86	30	60	44	30	25	5	.....	Finished in 1834.

TABLE B.—*Giving the cost and other particulars of the principal Graving Docks in the United States, and of the Dock at Quebec.*

12	Baltimore	1	Wood	0	0	437	450	470	111	45	80	48	27	22	1½	.....	" 1880.
13	Mare Island, California.	1	Stone	0	0	438	475	495	104	30	78	.....	32	26½	5	.....	Not yet completed.
14	Norfolk Navy yard	1	Stone	0	0	261	290	290	86	30	60	44	30	25	5	.....	Finished in 1834.

TABLE B.—*Giving the cost and other particulars of the principal Graving Docks in the United States, and of the Dock at Quebec.*

	PLACE.	Number.	Description.	When commenced.	Months in building.	Original cost.—$.	Cost of lengthening or deepening.—$.	Cost of Repairs.—$.	Total cost to date, not including interest.—$.	Approximate sum now needed for repairs to dock only.—$.	Number of main pumps.	Kind of main pumps.	Combined capacity of main pumps per minute, in gallons.	Number of hours required to pump out dock, water at ordinary high tide.	Average No. of vessels docked in a year.	Approximate total tonnage of vessels docked in a year.	No. of men required to dock a ship.	Cost of docking an ordinary ship.—$.	Cost of operating dock for one yr.—$.	Are ships repaired by Dock Comp'y?	REMARKS.
1	Quebec	1	Stone	1877	..	* 600,000	3,000	0	375,000	0	2	Plunger.	12,000	8	0	0	....	....	....	Unsettled.	Dock 3rds completed.
2	Portland	1	Wood	1868	15	300,000	0	.....	.....	10,000	2	Centrifugal.	40,000	3	.....	.....	8	....	....	No.	Both of these docks are owned by a Company.
3	"	2	Wood	1870	5									1							
4	Charlestown Navy Y'rd	1	Stone	1827	60	677,000	223,000	73,000	973,000	25,000	2	Lift.	1,600	6½	8	12,000	....	200	....	Yes	Owned by U.S. Govt.
5	Boston	1	Wood	1862	14	200,000	0	Small.	.....	Small.				3½				25			
6	"	2	Wood	1853	13	150,000	0	Small.	.....	6,000	2	Centrifugal.	40,000	1½	240	168,000	....	20	12,000	No.	All of these docks are owned by a private Company.
7	"	3	Wood	1855	4		0	Wood-work rebuilt 1875.	.....	Small.				½				8			
8	Brooklyn Navy Yard	1	Stone	1844	83	2,003,500	0	36,000	2,039,500	60,000	2	Lift.	.....	3½	5	10,000	32	171	7702	Yes	Owned by U.S, Govt.
9	Brooklyn	1	Wood	1864	15	783,356	500,000	included in first cost.	1,283,356	0	2	Centrifugrl.	70,000	2	150	400,000	8	22	....	Yes	Both of these docks are leased by W. Cramp & Sons.
10	"	2	Wood	1865	12									3							
11	Philadelphia	1	Wood	1875	9	300,000	0	0	300,000	0	4	Centrifugal.	80,000	2	75	150,000	9	22	4377	Yes	Owned by W. Cramp & Sons.
12	Baltimore	1	Wood	1879	14	365,500	0	0	365,500	0	2	Centrifugal.	60,000	2¼	30	36,000	6	30	2000	Yes	Leased by private Co.
13	Norfolk	1	Stone	1827	84	946,000	0	0	946,000	0	2	Chain.	.....	.....	.....	.....	....	..	....	....	Owned by U.S. Govt.
14	Mare Island, Cal.	1	Stone	1872	..	*2,500,000	.....	.....	1,450,000	.....	2	Centrifugal.	.....	.....	.....	.....	....	....	....	....	Owned by do. Dock incomplete.

* These figures give the estimated cost of dock on completion.

TABLE C.

Comparative cost of Stone Dry Docks at Quebec, and at the Navy Yards of Boston, Norfolk and New York,

CLASSIFICATION.	Quebec.	Boston. (Charlestown Navy Yard.)	Norfolk.	New York.
	Amount.	Amount.	Amount.	Amount.
Offices		$50,367 45	$37,365 92	$54,131 15
Tools and Fixtures	*$32,000 00	43,477 04	52,575 73	29,694 37
Temporary drainage		21,191 71	33,803 46	67,884 20
Pile wharves		19,886 03	24,995 09	9,423 60
Coffer dam	17,066 78	18,860 61	31 606 33	245,969 22
Excavations	60,641 15	32,055 45	53,572 33	141.425 49
Masonry	193,363 50	240,456 18	455.049 06	736,611 49
Culvert and well		24,301 22	13.762 02	43,519 89
Foundations		47,351 97	77,744 55	153,674 36
Gates or Caissons	37,699 55	60.731 88	46.709 97	158 884 61
Permanent drainage		14,861 88	29.945 22	84.520 84
Engine House	16,325,74	38,114 55	33,901 97	217.043 56
Removing Coffer dam		14.266 09	8,134 81	26,151 38
Embankment		20,558 08	11,468 72	15,543 62
Timber work	11.421 18			
Iron work	15,160 12			
Entrance at head	16,975 42			
Contingent	20,000 00	30,609 84	35,041 55	19,020 83
Totals	$420,653 44	$677.089 98	$945.676 73	$2003.498 61

* Cost of pumping machinery alone.

Note.—The Quebec dock is estimated to cost, when completed, about $600,000. The figures given for the Quebec dock are the contract amounts, except for the caisson, to which the duty ($7.154.25) and freight ($1,213.85) have been added. There must also be added about $10,000 for putting the caisson together and in place,—also the the following sums: about $35,000 for extras on coffer dam, $67,000 for an additional coffer dam, and $67,350 for engineering expenses, Inspectors wages and sundries.

To the Boston dock should be added $225,000 for lengthening 65 feet, and $73,000 for repairs.

To the New York dock should be added about $15,000 for repairs and $21,000 for repairs to gates and caisson.

The opinions of Civil Engineers—who have been or are connected with different dry docks—vary widely as to the relative merits of wood and stone for construction purposes. Some prefer wood solely on the score of economy in the first cost, others give it their preference on account of various alleged advantages, and would adhere to it even if a stone structure could be built as cheaply, while others again say, "adopt stone if you can, and have nothing to do with wood."

I had the good fortune to meet the Chief Naval Constructor of the United States and several of the constructors attached to different navy-yards. These gentlemen have the direct charge of docking the ships of war, and are constantly supervising work done in and about the Government stone docks, their opinions, consequently, ought to be of considerable value. They all expressed a high opinion of wooden docks, some very strongly, others gave reasons for their preference which—from an engineering point of view—might be considered insufficient, and others thought the advantage lay solely in the saving effected in the first cost.

A very strong argument advanced was, that the Government contemplate extending, by the use of timber, one of their existing stone docks, but this statement was not confirmed by any of the Government Engineers. The strongest objection, however, against the use of stone was that the existing granite docks had caused the death of many men by reason of their constant dampness.

The chief points of advantage of wooden docks over those of stone are said to be:

1st. That they are dryer and consequently more comfortable and healthy for the working men.

2nd. That the wooden dock is cooler in summer and warmer in winter than the stone one; because the stone gets so hot under a summer sun that it can scarcely be touched, while in winter the sides of the dock are coated with ice.

3rd. That ice, if it should form on a wooden altar, is much easier removed than it could be from stone.

4th. That the facilities afforded to the workmen—both in docking a ship and in passing in and out of the dock at any point, while repairing her—by reason of the low and narrow altars*—are superior to those of any existing stone docks, and consequently, that the operating expenses are greatly reduced.

5th. That the form of the altars also renders all cutting of shores unnecessary.

6th. That the annual cost of repairs is less than for a stone dock.

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* Stone docks having low and narrow altars from bottom to top—the same as the American wooden docks—are said to exist in some European ports.

7th. That even if the timber face of the dock should decay and require renewal every twenty years or less, the interest on the saving in the first cost would be much more than sufficient to meet this contingency.

8th. That a wooden dock can be built at a cost of from one-third to one-half that of a stone structure of similar size.

The above arguments are advanced by the advocates of wooden docks, after comparing modern and new timber structures with comparatively old and imperfectly constructed docks of stone, and I do not think the comparison a fair one. There are no modern stone docks yet completed on this side of the Atlantic to which reference can be had in order, justly, to compare the merits of each style.

The old stone docks in Boston and New York are clearly objectionable on account of their dampness, and the cause of this dampness is largely attributable to the absence of any provision —in the original plans—for underdrainage. If proper provision be made, in this respect, from the inception of the works to their completion, and the best hydraulic cement be used for mortar, I can see no reason why a stone dock, or one of brick, or one of concrete throughout, could not be made dry and free from leakage and the effects of frost. With the leakage removed the accumulations of ice on the sides and floor of the dock would also be removed, except so far as rain and sleet might cause trouble, and in that case the difficulty would be quite as great in the wooden as in the stone structure, except that the ice would remain longer clinging to the stone than to the wood.

The advantages claimed as to the low and narrow altars can be equally applied to a stone dock, because the stones can be dressed to that shape as well as to any other, and therefore all cutting of shores can be avoided in the stone as well as in the the timber structure.

As to the 6th, 7th and 8th items of advantage, they are partly matters of calculation, and require to be carefully considered.

If a stone dock were built in such a manner that the joints were all perfect and tight, and all water could be drained from the back of the masonry so that frost could not affect it, the cost of repairs in that case would be nothing, as it is frost alone which has caused the whole trouble in the maintenance of American stone docks.

"A Board of Inspectors," consisting of officers of the Navy, Civil Engineers and Naval Constructors, appointed by the United States Navy Department, about a year ago, to examine carefully and give their opinion upon "Simpson's timber docks," stated in their official report that "it would appear that the life "of timber docks is as yet, unknown, though the substructure, "which is kept constantly wet, can be said to be practically

"imperishable. Judging from all the information obtainable, "we are of the opinion that the repairs of a timber dock of good "quality, of good materials and well built, would be insignificant "for a period of say twenty years, when it would probably be "found necessary to renew all the wood work above high water "level, and the face timber above half tide level. The relative "average yearly cost of repairs of these docks—as now con- "structed—and the ordinary stone docks, in our opinion would "be in favor of the timber docks, especially in latitudes above "the frost line. The manner and cost of operating does not "appear to differ materially from other kinds of well-constructed "excavated docks."

The question of the action of sea or ship worms upon the wood work of a timber dock does not appear to have been alluded to in the above-mentioned report, and the probable reason was that these worms have never been known to attack the wood work of any of these docks. It is easy to account for this, as all sea worms require a constant supply of salt water to keep them alive.

The Teredo lives almost entirely under water, below tide level, (and this species of worm exists only to a limited extent and does not thrive in the Harbour of Halifax,) while the little Limnoria, our greatest pest, commits his ravages between low and high water mark, and when deprived of a return of tide he dies. As vessels often remain in dock for days together, the Limnoriæ of necessity cannot live, and consequently the wood-work, even in the oldest stone docks (the original wooden keel blocks) never shows signs of having been affected by sea worms.

While entertaining a high opinion of the value of timber docks, in suitable localities, and under circumstances favourable to their construction and maintenance, I cannot wholly concur in the conclusions at which the United States Board of Inspectors arrived. They seem to me to be based upon insufficient data, and the fact that the wood work of No. 2 Dock at Boston had to be entirely renewed after twenty years' service appears to have required more notice and searching investigation than it received, at least so far as can be gleaned from the report.

One of the chief advantages of a well-constructed timber dock is said to be that the interior is left perfectly dry after the water has been pumped out, and, as was before stated, a ship often remains in dock for many days, it follows that the face is left alternately wet and dry, and there is no condition which hastens more speedily the decay of wood than this. Our cheapest native timbers are hemlock and spruce, and each should be chemically treated to make it serviceable for the face of a wooden dock. Any process adopted to preserve these timbers from decay will be found expensive, and the result would

probably be unsatisfactory, as they naturally split and crack badly when subjected to the action of the weather, and are therefore unsuitable for use in exposed positions.

Our ordinary white pine is an expensive wood and is yearly becoming more scarce and valuable. It is good and suitable for use in dry situations, but is objectionable in large dimensions by reason of its liability to dry rot, and it rapidly decays when subjected to the action of moisture or alternately wet and dry.

The only available timber which is suitable for the construction of a wooden dock is Southern, Georgia, or pitch pine. When of good quality it is heavy, close grained, elastic and durable, and when the sap wood is removed it will remain sound for a long time in damp localities. It is however, in this country, very expensive, being worth about fifty cents per cubic foot, in a rough state, delivered at Halifax. To arrive at its value fixed in place, in a finished work, it would not be safe to estimate less than seventy cents per foot, or say $19 per cubic yard. As this is a higher price than is usually paid for granite masonry in this city, it is clear that the saving effected by the adoption of pitch pine in the face of a dock would not be as great as may be generally supposed. That there would be a saving is undoubted, even though the wood should cost much more per cubic yard than stone, because the quantity of the former material required is much less than the latter, as the stones have necessarily to be well bonded with the backing, while the wood forms simply a lining.

The great saving effected by the adoption of a timber dock (as constructed in the United States) is by reason of the absence of all backing in the structure, clay puddle being substituted and rammed in solidly against the wooden altars as they are placed in position, and built upwards. In the best timber docks concrete has been liberally used at and about the entrance, so that the portions of the work exposed to the action of ship worms are well protected, and only a veneering of wood work in those places will require renewing.

I think it would be a mistake to adopt a structure of this description in this port, and if it should ultimately be decided to adhere to wood for the face of the dock, it would be advisable to build a heavy backing of the best Portland cement concrete and to bed the timbers upon this material, in other words, it would be an artificial stone dock with a wooden face.

For the purpose of enquiring into the cost of maintenance of such a structure, it may be assumed that the heart of the work would be indestructible and permanent, while the wooden portions, which would be mostly exposed, would require periodical repairs and renewing.

Although the wood work in timber docks elsewhere is said to have been in use ever since their original construction—covering a period, in one case, of twenty-nine years—I do not think it would be safe in this climate to assume that the timber would endure, under the most favorable circumstances, for a greater length of time than twenty years without having to undergo very extensive repairs in that period.

The dry dock required at this port will be one of the largest in America, and if we assume that it can be built for a certain sum of money, and can arrive at an approximate amount for repairs and renewal of the perishable parts in a given period of time, it is not a difficult matter to determine the relative merits financially of such a structure as compared with another which would cost more in the first instance and less for repairs afterwards.

As it is impossible to make any reliable estimate of the first cost of a dock until the site is known and, at least, approximate data as to details be given, it becomes necessary for the purposes of comparison—to assume a probable cost for the construction of one description of dock or the other.

If $500,000 be taken as the first cost of a stone dock, and an allowance of $10,000 be made for repairs required in every 20 years, the relative value of a dock which would never need any repairs would be $506,050, because the difference would yield at compound interest, (assuming money to be worth five per cent,) the sum necessary to cover the cost of repairs in that time. The relative value of a timber dock may also be arrived at in the same way. If a similar sum of money be allowed for the general repairs to the wood work of a timber dock, and $50,000 be taken as the cost of entirely renewing the wooden face every 20 years, then—for the reason given above—the equivalent value of the timber dock, with concrete backing, would be $469,750, and of a dock requiring to be wholly rebuilt every 20 years, $315,303.

Working upon the same data as to cost of repairs and renewals, durability and the value of money, but assuming other values for the cost of a stone dock, the figures would stand thus:

Assumed cost of a stone dock that would never need any repairs.	Equivalent value of stone or concrete dock requiring $10,000 in repairs every 20 years.	Equivalent value of concrete dock with pitch pine face, requiring $60,000 in repairs and renewals every 20 years.	Equivalent value of a wooden dock requiring entire rebuilding every 20 years.
$ 500,000	$ 493,950	$ 463,700	$ 311,534
600,000	593,950	563,700	373,841
800,000	793,950	763,700	498,454
1,000,000	993,950	963,700	623,068
2,000,000	1,993,950	1,963,700	1,246,136

These figures will stand about the same if the wood work of the timber docks be assumed to last for 25 years without renewing, and money be taken as worth four per cent.

The relative values here given are not mathematically correct, because the repairs account would be a running one and not payable in a lump sum every 20 or 25 years. The results, however, are sufficiently near the mark to enable a fair conclusion to be arrived at, and, practically, they may be taken as accurate, because the errors in each case would about balance.

The cost of a dry dock must necessarily depend to a great extent upon the locality selected for its construction. If the site be one where there is difficulty in obtaining a solid foundation, or where the water cannot easily be excluded during construction, the first outlay will probably be heavy, no matter what kind of dock may be adopted. The primary cause of the great cost of some of the American stone docks has been that the foundations were bad, or much difficulty was experienced in getting rid of the water and in keeping the coffer-dams tight. Troubles of a similar nature have been experienced at the entrance to the Quebec dock, and have entailed additional expenditures, already, of over $100,000, besides causing great delay in the completion of the dock.

The cheapest site upon which a graving dock could be built, would be one where the excavations were through some water-tight material, and well clear of the water's-edge, so that no expensive coffer-dams would be required. The channel leading to the entrance could then be excavated and dredged out after the whole structure had been completed on dry land. We cannot hope, however, in this port, to obtain so favorable a site, especially in a locality which would answer in other respects, and it may be taken for granted that the items "coffer-dams" and "pumping" will form no inconsiderable part of the first cost of our dock, unless, indeed, the result of surveys and careful borings should show the ground to be more favorable than the surface would indicate.

As to the relative cost of the different materials which may be employed in the construction of a dry dock, the following prices may be taken as a guide:—

Pitch-pine built in place..	$19 00	per cubic yard.
1st class granite masonry..	17 00	" "
Brickwork in cement.....	11 00	" "
Best rubble backing	5 00	" "
Portland cement concrete..	4 50	" "

Pitch-pine undoubtedly possesses advantages over any of the other materials for the internal face and altars of a dry dock. Its chief merits seems to be that it may be expected to last longer and in a more perfect state than other kinds of wood in

the same situation, that it does not absorb cold in winter nor heat in summer to the same extent that stone, brickwork or concrete would do, and consequently, it is more comfortable and healthy for the workmen than either of those materials. Also, that it is much easier to keep the dock clear of accumulations of ice and snow when the altars are of wood than if of any other substance. Its disadvantages are that it is a foreign and expensive wood, and that its durability cannot be assured.

The conclusions at which I have arrived, after giving these matters careful consideration are, that a well-constructed dock, built with concrete backing and a granite face, would be the best in this port. That a concrete dock with pitch-pine facing would stand next as regards cost and would prove an excellent and serviceable structure for a number of years. That a dock built almost entirely of concrete would be a good and durable structure, and that it would be considerably cheaper than the dock faced with pitch-pine. Finally, that a dock faced with timber and backed only with clay puddle—in the usual way that wooden docks have thus far been built—while being probably the cheapest, would not prove satisfactory for any length of time in this country.

There are several other descriptions of docks and appliances which have been invented in order to enable workmen to obtain easy access to the bottoms of vessels for the purposes of examination or repairs. Of these the best known in this port is probably the Marine Slip or Railway, of which we have three, the largest being capable of drawing a ship of 2,500 tons out of the water. The principal other kinds of docks are:

1. *The Balance or Floating Dock.*—This is a huge wooden construction, into which the vessel is towed or hauled. The water-tight compartments are then pumped out and the dock, with the ship upon it, gradually rises out of the water. The great drawback to this dock here would be that the bottom would soon be destroyed by worms and it would be inaccessible for repairs.

2. *The Sectional Dock.*—This may be compared to a Balance dock, cut transversely into separate pieces or sections of about 30 feet in length. The sections are made of timber, and as many are placed together as may be needed to raise a ship of any length. There are connecting beams joining the several sections together, which are keyed up after the vessel has been lifted, so that the different parts become as one structure. Vessels can be transferred from the dock to ways upon the shore by means of a cradle worked by hydraulic power, but the operation is said to be one requiring great care and has not unfrequently resulted in accidents of a serious nature.

3. *Iron Floating Docks* are of various shape and design, probably one of the largest in existence is that at Bermuda, which is 330 feet in length by 84 feet in width inside. The bottom is flat and the sides curved, so that the outline roughly assumes the shape of a vessel amidships, and the ends are open. It is divided lengthwise into eight water-tight compartments and transversely into three on each side. It is provided with two caissons and can take in vessels drawing water up to 26 feet. Its cost is said to have been about $1,200,000. One of the objections to a dock of this description seems to be that the difficulty of reaching the bottom for the purpose of cleaning or repairs is great and expensive, besides being attended with no small risk to the entire structure.

An iron floating dock 300 feet in length by 72 feet in width inside was constructed in 1866 at St. Thomas. It was composed of six pontoons, each of which was divided into three water-tight compartments. The sides were formed of girders resting upon the pontoons and between the girders were placed large floats, the object being to counteract any tendency in the structure to cant and to prevent it from sinking too far. Soon after its completion, however, an accident occurred and the whole dock sank to the bottom, where it remained for a considerable time.

4. *Depositing Docks.*—The first dock of this description is said to have been constructed at the Arsenal of Nicolaieff, in the Black Sea, for the Russian Government in 1877. It was designed for the purpose of raising the large circular iron-clads and the ordinary iron-clads of the Russian navy, and will lift a dead weight of about 4,000 tons. It has but one side, which is 280 feet long, 44½ feet high, and 12 feet broad, and is divided into three similar lengths, which can be attached or detached at pleasure. To each is fastened a series of pontoons or "fingers" on one side, which are passed beneath the vessel to be raised. On the other side is a sliding out-rigger which balances the dock and prevents it from tipping over. A ship is raised by pumping the water out of the pontoons, and when at a sufficient height the dock, with the ship upon it, is drawn sidewise to a staging along the shore. The staging is built of piles arranged in parallel rows in such a manner that the pontoons supporting the ship pass between the rows just as the fingers of one hand, if extended a little, may be made to fit between the fingers of the other. When the pontoons are in this position they are allowed to fill with water, partially sink, and be withdrawn so as to be ready for use again, the ship, of course, being left standing upon the stage. In this way any number of vessels can be deposited high and dry out of water with the one dock, the limit being simply the length of the staging.

This dock is said to have cost between £100,000 and £200,000 sterling—as first built—but in 1880 its capacity was enlarged so that it can now lift up to 6,000 tons. The Russian Government have recently completed another dock of the same description to raise vessels up to about 8,000 tons displacement.

The chief objectionable features of this dock, and in fact of all floating docks consisting of several sections or pontoons are said to be—1st. Difficulty in properly supporting a vessel on the dock. 2nd. The practical impossibility of so emptying the different pontoons or sections that great strain will not be brought upon the vessel.

5. *The Hydraulic Lift Dock.*—This dock is constructed with two rows of hydraulic presses and rams, which serve to raise the vessel; between these are suspended "a number of transverse girders forming a gridiron, which supports a pontoon upon which the vessel when raised, is ultimately floated." The dock is said to be adapted to localities where the rise and fall of tide are small.

6. "*The Hydraulic Grid*" bears much resemblance to the last-mentioned dock. The vessel is raised by hydraulic presses and rams, but the presses are placed directly beneath the vessel to be raised, and thus the cross girders, the pontoon and other portions of the former dock are dispensed with in this case. The weight of the apparatus to be lifted and the cost of the dock are thus greatly reduced. It is claimed that "in favorable positions "hydraulic grids may be constructed at a cost of £5 per ton of "dead weight to be docked, while as compared with patent slips, "they have the advantage of occupying very little space, and "of raising vessels on an even keel without the slightest strain."

7. *The Double Power Dock.*—This is an iron floating dock with flat bottom and upright sides. The sides, corners and bottom are in separate pieces or pontoons, and can either slide one within the other or be made rigid. The upper portions of the sides are converted into machine and workshops. The great advantage which this dock possesses over all other descriptions of floating docks is that all the portions below water can readily be got at, as one part of the structure can be made to dock any other part. In this way it can always be kept well cleaned and painted, so that its length of life would be greatly prolonged. It is claimed that with care it will last a hundred years. The objections to a floating dock, even of the best description, seem to me to be that the items, cleaning, painting and maintenance must necessarily amount to a large sum annually, besides which there is always the risk of an accident occurring by which the whole structure might be suddenly precipitated to the bottom.

A dock of the above description (the double power dock) to lift a ship of 4,000 tons dead weight, I am assured by the agent for the patentees, could be placed in Halifax Harbour complete in every respect (duty paid) within eighteen months after the

order for it is given, at a cost of $500,000. The cost of a larger dock of the same kind has not been given.

8. *Floating Coffer Dams.*—These may be compared to a miniature timber floating dock, or a box with three sides and a bottom, the fourth side being cut out roughly to the shape of a ship. This dock is generally taken to the ship, and not the ship to the dock, as in other cases. The dock or coffer dam, being submerged, is placed under the bow or stern of a vessel, her section having been previously ascertained, and the open side of the box made to correspond to the same with water-tight packing. The water is then pumped out, and the workmen can at once descend to the bottom of the vessel.

These coffer dams, although no doubt useful and serviceable in many cases, admit of access being had only to the bow or stern of a vessel; they can therefore never entirely supercede the dry dock.

There are many important details in connection with permanent docks, both of wood or stone, to which no reference is here made on account of the length that this report has already reached. There is, however, one matter which seems to me of such importance that attention may not now improperly be directed to it, in order to show that the number of ocean-going steamships which enter this port is considerably greater than those which enter some other ports where large graving docks have been found necessary. An opportunity will thus be afforded to those who care to enter upon the calculation, to estimate the probable paying qualities of the proposed dock. They should however, bear in mind that Halifax lies close upon the track of vessels trading between Great Britain and the northern ports of the United States, and consequently it is to be expected that many an "Ocean Tramp"* and other vessels disabled in mid-ocean will make for this port for repairs if proper facilities could be offered.

Ocean going steamships are here specially referred to because it is vessels of that class to which the owners of a large graving dock must look for their greatest amount of business and profits.

In the year 1881 there entered the port of Halifax 584 steamships, ships and barques, having a registered tonnage of 564,117 tons. Of these, 494 were steamers of 514,688 registered tons.

The total number of ocean steam vessels which entered all the ports of the United States in the same year was 4,222, and their total tonnage was 8,727,688. If the returns from the port of New York be deducted, the result shows as follows:

Total number of ocean steamers entered inwards at all other ports in the United States	2,308
Total tonnage of ditto.....	3,888,557

* A name given in America to iron steamships cheaply built and of inferior quality.

These figures refer only to the steam vessels engaged in the foreign trade of the country, and compared with similar returns from the ports of Halifax, Baltimore and Quebec, they stand thus for the year 1881:

STEAMSHIPS ENGAGED IN FOREIGN TRADE

Entered inwards at	Halifax	362.	Tonnage,	459,278
"	Baltimore	311.	"	.....
"	Quebec	157.	"	292,297

Correct returns from other ports have not yet been received, but will be added in an appendix, together with more full returns from the above ports, if they can be obtained.

From the above it will be seen that the number of ocean steamships entering the Harbour of Halifax is nearly twenty per cent. more than at the port of Baltimore, and exceeds the entries at Quebec Harbour by over one hundred and thirty per cent.

When it is also considered that the St. Lawrence is sealed up by ice for five months out of the year; that this is the natural Winter Port of the Dominion, and Her Majesty's chief Naval Station in North America, besides being the Atlantic terminus of our great inter-provincial system of railways, and, in a military point of view, the key to Canada, I do not think that much stronger arguments need be urged to impress upon both the Imperial and Dominion authorities our claims to substantial aid in so important an enterprise as the Halifax Graving Dock.

Your obedient servant,

E. H. KEATING.

ERRATA.—Page 19, line 14 from bottom,—for No. 2 read No. 3.

COMPARATIVE STATEMENT shewing the number and registered tonnage of vessels engaged in Foreign Trade, at some of the principal Ports in the United States and Canada, during the years 1881 and 1882.

Arranged in order, according to the number of Ocean Steamships frequenting each port.

	Vessels arrived from Foreign Ports during 1881.								Vessels arrived from Foreign Ports during 1882.							
	Ocean Steamships.		Ships.	Barques.	Brigs and Brigantines.	Schooners.	Total No. of vessels of all classes.	Total Tonnage.	Ocean Steamships.		Ships.	Barques.	Brigs and Brigantines.	Schooners.	Total No. of vessels of all classes.	Total Tonnage.
	No.	Tonnage.							No.	Tonnage.						
All Ports in the United States	4,222	8,727,688	.....	.....	.....	.....	33,815	18,319,204	.....	.....	.....	.....	.....	.....	.....	.....
New York	1,914	4,839,131	.....	.....	.....	.....	7,157	7,506,522	.....	.....	.....	.....	.....	.....	6,476	.....
Boston	471	957,928	38	320	332	1969	3,130	1,508,018	481	909,513	.....	.....	.....	.....	2,961	1,391,394
Halifax	362	*459,278	3	81	237	359	1,042	576,916	354	*432,054	6	94	244	405	1,103	561,492
Baltimore	313	.....	83	670	100	121	1,287	1,222,928	284	.....	33	293	81	125	816	790,703
Philadelphia	.....	.....	.....	.....	.....	.....	1,279	946,129	.....	.....	.....	.....	.....	.....	.....	.....
Portland	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Montreal	217	366,417	4	60	24	52	357	432,551	.....	.....	.....	.....	.....	.....	.....	.....
St. John, N.B.	216	210,809	.....	.....	.....	.....	1,222	494,378	216	230,675	.....	.....	.....	.....	1,342	423,506
Quebec	157	292,297	.....	.....	.....	.....	678	722,665	142	268,868	.....	.....	.....	.....	610	652,951
St. John's, Nfld.	28	27,139	.....	.....	.....	.....	331	47,239	26	19,504	.....	.....	.....	.....	279	42,247

The above information has been obtained from the following sources:—New York Chamber of Commerce, New York Maritime Register, Boston Custom House, Halifax Harbour Master, Baltimore Journal of Commerce, Philadelphia Maritime Exchange, Montreal Harbour Commissioners Report, Gilbert Murdoch, Esq., M. Am. Soc. C.E., St. John, Quebec Harbour Commissioners Report, Harbour Master, St. John's, Nfld.

*For the Port of Halifax the *nett* registered tonnage is given. The *gross* registered tonnage would be about one-third greater.

Quebec	191	202,201	.....	.....	.....	.....										
St. John's, Nfld.	28	27,139	.....	.....	.....	.....	331	47,239	26	19,504	.....	.....	.....	.....	279	42,247

The above information has been obtained from the following sources:—New York Chamber of Commerce, New York Maritime Register, Boston Custom House, Halifax Harbour Master, Baltimore Journal of Commerce, Philadelphia Maritime Exchange, Montreal Harbour Commissioners Report, Gilbert Murdoch, Esq., M. Am. Soc. C.E., St. John, Quebec Harbour Commissioners Report, Harbour Master, St. John's, Nfld.

*For the Port of Halifax the *nett* registered tonnage is given. The *gross* registered tonnage would be about one-third greater.